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(54) Title: **IMPROVEMENTS IN AND RELATING TO WASHING MACHINES**

(57) Abstract: A washing machine wherein a drum-containing casing is supported within a cabinet so as to permit relative vibratory movement between the casing and the cabinet. The interior of the casing is sealed against loss of liquid and can accommodate an internal pressure above or below ambient. The support comprises resiliently extensible struts between the casing and the cabinet which generally centre the casing therewithin. A corrugated bellows surrounds and seals a circular opening in an end wall of the casing and at its other end a circular opening in an adjacent wall of the cabinet. The latter is closable by means of a door which seals to the opening therein. The corrugations are reinforced by at least one reinforcing helix or spiral in the form of a helical spring, which prevents the material forming the bellows sleeve from stretching or collapsing due to an increase or decrease in the pressure within the casing relative to ambient pressure outside the casing. The drum may be circular or pseudo-elliptical, when viewed axially. Water and detergent inlet ports, an air inlet port, an outlet port and a connection for a pressure gauge are located at a plurality of circularly spaced points around the cylindrical wall of the casing. Liquid can be supplied from a circulating pump which collects liquid from the housing and recirculates it under pressure preferably tangentially back into the housing. Incoming air is heated to 40°C. A heater is provided between the outer wall of the drum and the wall of the casing. An opening in the bellows supplies air to the casing during spin drying, or a diffuse mixture of water vapour and steam during washing. During drying air and water are drawn out of the casing by means of a suction pump (typically a venturi pump) so that a pressure lower than ambient exists during drying. A positive pressure in the range 1 to 5 psi over ambient is maintained in the casing and the drum during washing. Blades are fitted to extend radially of the drum wall. Where they protrude externally of the drum they assist in distributing air and liquid and diffusing vapour within the casing. A second drum or basket can be fitted within the first.

WO 03/012185 A2

Title: Improvements in and relating to washing machines

Field of Invention

This invention concerns washing machines

Background to the invention

It is known to mount a drum for containing articles to be washed, within an outer casing. The drum is rotatable about a horizontal axis and the casing is larger than the overall dimensions of the drum so that the latter can rotate freely within the casing whilst the latter remains stationary.

Conventionally access to the drum is through a circular opening in one end face, and the casing is formed with a similar opening in alignment with that in the drum to allow access to the interior of the drum.

The casing is normally suspended within a cabinet which serves to house the motor for rotating the drum, the detergent reservoir and dispensing mechanism, the pump for pumping water out of the drum and casing after washing and rinsing cycles, and the control system for controlling the operation of the motor and pump etc., to perform washing and rinsing cycles, and if provided, a spin-dry cycle.

In the same way as the casing is provided with an opening which aligns with the circular opening in the drum, the wall of the cabinet which is adjacent the apertured wall of the casing is also formed with a circular opening and a door is provided, hinged to the cabinet for closing the opening in the cabinet wall.

Typically the cylindrical wall of the drum has been perforated to allow water to pass between the drum and the casing.

A flexible seal has normally been provided which co-operates with the door to prevent leakage of water when the door is closed.

A washing machine as hitherto described will be referred to as a washing machine of the type described.

It is an object of the present invention to provide an improved method and apparatus for mounting a drum-containing casing within a washing machine cabinet.

It is another object of the present invention to provide an improved method and apparatus for sealing the access opening in the casing to prevent water loss.

It is a further object of the invention to provide improved diffusion of water and vapour within the interior of the casing and drum, to improve the permeation of cleaning liquid (detergent etc.) into the articles forming the washing load.

Summary of the invention

According to one aspect of the invention in a washing machine of the type described the casing is mounted on a plurality of legs which extend between the exterior of the casing and the interior of the cabinet, especially to the floor and/or lower regions of the side walls of the cabinet.

At least one additional leg may be provided to extend between the exterior of the casing and upper regions of one or both sidewalls of the cabinet.

In order to accommodate out of balance forces when the drum is rotating each leg may include or comprise a shock-absorbing device.

Typically each leg comprises an extensible two part strut, relative movement between the two parts of which is governed by a spring.

Typically the unrestrained length of the struts is greater than the distances between the casing and the cabinet which they are to span, so that when the casing is mounted within the cabinet the struts are partly compressed, so that the overall length of each strut can increase and decrease, its spring thereby becoming less or more compressed, to accommodate the changes in overall length.

Preferably the struts extend in directions which are not radii of the cylindrical casing, at an acute angle to the casing and the cabinet, so that any change in length can be considered as dimensional changes in directions parallel and perpendicular to a plane containing the axis of rotation of the drum.

By mounting the struts in this manner, movement of the casing from front to back and/or vertically up and down, within the cabinet, is permitted simply by co-operative variations in the length of the struts.

The invention thus comprises a method of supporting a drum-containing casing within a washing machine cabinet by means of a plurality of resiliently compressible and extensible struts between the casing and the cabinet, whereby the casing floats within the cabinet and is capable of relative movement therewithin during rotation, caused by unbalanced loading of the drum.

According to another aspect of the present invention the drum includes an axially extending stub shaft which is received in and supported by a bearing assembly carried in or by the end wall of the casing opposite that containing the access opening.

Preferably the bearing assembly comprises two sealed ball or roller bearings the outer race of each of which is secured within a hub-extension of the end wall of the casing and the inner race of each of which is secured to the stub shaft extending from the drum.

Between the bearing assembly and the drum is preferably located one or more seals which prevent air or liquid from escaping therethrough.

In order to rotate the drum a pulley may be keyed or splined to the stub shaft where it extends beyond the bearing assembly. An electric motor is mounted to drive the stub shaft via a drive belt.

A gearbox may be provided driven by the electric motor.

A pulley may be mounted on the outlet shaft of the gearbox or the motor to transmit drive to the pulley on the drum stub shaft via a drive belt.

According to another aspect of the invention where high rotational speeds of the drum in excess of 450rpm are required so as to spin dry the articles, a cylindrical sleeve, capable of axial enlargement and contraction, but resistant to circular enlargement or contraction, is sealingly secured at one end around the circular access opening in the end wall of the casing and at its other end around the circular access opening in the cabinet wall.

In a preferred arrangement the sleeve is formed from rubber or plastics or a combination thereof and is formed with at least one radial corrugation to form a cylindrical bellows and at least one loop of wire surrounds or is embedded in the wall of the corrugated sleeve so formed to resist circular enlargement or contraction, of the sleeve, without interfering with the ability of the sleeve to axially expand or contract and/or for one end to be displaced relative to the other due to vibration of the casing relative to the cabinet.

The sleeve may be formed with a spiral corrugation the peaks and/or troughs of which are reinforced with one or more wire spirals. Typically a smaller radius spiral is embedded in

the troughs, while a larger radius spiral is embedded in the peaks of the spiral corrugations of the sleeve material.

Circular or radial displacement of the casing due to out of balance forces during rotation of the drum (as can occur when filled with articles such as clothes, for washing), is accommodated by distortion of the corrugated sleeve with one end moving in a plane perpendicular to the axis of the sleeve relative to the other end of the sleeve. Front to back movement of the casing is accommodated by lengthening or shortening of the sleeve, in a direction parallel to the sleeve axis. In this way the gap between the wall of the casing containing the access opening and the adjacent wall of the cabinet is sealed at all times, even during unbalanced rotation of the drum, which can cause the casing to shake and vibrate within the cabinet.

It is a preferred feature of a corrugated sleeve constructed as proposed, that the resistance to circular enlargement or contraction of the sleeve allows the pressure within the casing to be greater or less than ambient without interfering with the integrity of the seal between the casing and the cabinet.

The bellows may be of stainless steel or plastics or rubber or a composite of rubber and plastics.

If the maximum speed of the drum is to be 450 RPM, such that drying is only achieved to a damp-dry condition, the sleeve may be replaced by a flange of stainless steel, plastics or rubber or a composite thereof.

The invention therefore also lies in a method of supporting a washing machine drum-containing casing within a cabinet whilst permitting relative vibratory movement between the casing and the cabinet and so that the interior of the casing is sealed against loss of liquid and can accommodate an internal pressure above or below ambient, by means of resiliently extensible struts between the casing and the cabinet to generally centre the casing therewithin, and a corrugated bellows sleeve seal surrounding at one end an opening

in an end wall of the casing and at its other end an opening in an adjacent cabinet wall, which latter is closable by means of a door which seals to the opening therein, and the corrugations are reinforced by at least one reinforcing helix or spiral in the form of a helical spring, which prevents the material forming the bellows sleeve from stretching or collapsing due to an increase or decrease in the pressure within the casing relative to ambient pressure outside the casing.

The reinforcement may for example be of wire or rigid plastics material.

Preferably the inner rim of the circular access opening in the cabinet wall is lined with a ring of resiliently deformable seal material such as rubber or plastics or a composite thereof, and the door extends at least partly into and through the end of the bellows seal when the door is closed, and forms with the ring a fluid tight seal which resists inward or outward flow of air or liquid when the door is fully shut. An internally protruding part of the door preferably sealingly engages the ring of resiliently deformable seal material around the cabinet opening.

The ring seal around the rim of the opening in the cabinet wall may be formed by or secured to an annular region of the cabinet-engaging end of the corrugated bellows seal.

Preferably a cylindrical lip extends from the rim of the circular opening in the drum into the circular opening in the casing, so that there is little tendency for articles or parts of articles in the drum to become drawn into the gap between the drum and the casing. A clearance between the outside of the lip and the circular opening in the casing allows for rotation of the drum relative to the casing.

The drum need not be cylindrical but instead may be generally or pseudo elliptical, when viewed axially. In that event the major axis of the generally elliptical (or pseudo elliptical) shape must be less than the internal diameter of the cylindrical casing, so as to be capable of rotating freely therewithin.

According to a further aspect of the invention, especially but not exclusively in the case of a generally elliptical or pseudo elliptical drum, strengthening ribs may be provided extending along perpendicular diameters of a cylindrically shaped drum, or the major and minor axes of a generally elliptically or pseudo elliptically shaped drum. The ribs may extend internally of the drum, but preferably extend parallel and close to, internally or externally of the drum, in contact with, or attached as by welding or riveting to, or are formed integrally with, the end wall of the drum opposite the end containing the access opening.

Water and detergent inlet ports, an air inlet port, an outlet port and a connection for a pressure gauge may be located at a plurality of circularly spaced points around the cylindrical wall of the casing.

In accordance with a further aspect of the invention three inlet ports are provided, one for admitting hot or cold water or soap, a second for admitting heated air, typically at 40°C, and a third for admitting fluid into the drum to which liquid is supplied from a circulating pump which collects liquid from the housing and recirculates it under pressure back into the housing.

Preferably the third inlet introduces fluid tangentially into the drum.

Preferably the outlet port is at a remote location from the three inlets.

Preferably the outlet port is situated at a point around the casing which, when the latter is located within the cabinet, will be at the lowest point of the casing when the cabinet is standing on a horizontal surface, to facilitate the removal of liquid from the casing as by draining and/or suction withdrawal.

According to another aspect of the invention a heater is provided between the outer casing of the drum and the wall of the housing within which the drum is located and rotated, and this is employed to heat liquid before it leaves the housing to be pumped under pressure

back into the housing. This allows a mixture of water vapour and steam to be pumped back into the drum, and also allows water at a lower temperature of around 40°C to be employed initially, this water being withdrawn and heated and converted to steam for injection under pressure back into the drum.

The diffuse mixture of water and steam may be pumped into the drum during washing via an opening in the bellows.

According to a further aspect of the invention the same opening in the sleeve can be employed to supply air to the housing during spin drying, or the diffuse mixture of water vapour and steam during washing, depending on the operation of one or more valves controlling the fluid which is supplied thereto.

During vacuum assisted drying air and water are drawn out of the housing by means of a suction pump, and in accordance with another aspect of the invention, the same pump may also be employed to draw water out of the housing during washing and rinsing, the extracted water passing from the pump to a drain, or via a pipe means to the opening in the drum for recirculation under pressure.

Preferably the suction pump is a venturi pump, preferably a high vacuum venturi pump.

If according to the said further aspect of the invention heated air is introduced into the drum via an opening in the wall of cylindrical sleeves at one end of the rotatable drum, heated air will be able to reach the central region of the drum in general without having to pass through items in the drum, but in general will have to pass through those items before it can leave the drum via openings in the wall of the outer stationary housing.

According to another aspect of the present invention it is proposed that a positive pressure over ambient is maintained in the housing and drum during washing and a preferred range of positive pressures in the housing is 1-5 psi over ambient.

It has previously been proposed to cycle vacuum and pressure during a vacuum assisted tumble dry cycle, but according to another aspect of the invention it is proposed to avoid the need to cycle in this way by introducing hot air via the bellows during a vacuum assisted tumble-dry cycle, and where tumble drying is accompanied by reduced pressure in the drum, it has been found advantageous to maintain the vacuum suction on during the whole tumble dry cycle, to remove the hot air introduced into the drum.

It has previously been proposed to use water from the drum that has been used for washing or rinsing for activating the venturi pump when fitted. Typically 8-9 litres of such water are stored in a reservoir in the machine for actuating the venturi pump, and in accordance with another aspect of the invention the reservoir is continually topped-up with water as it is drawn from the housing by the main suction pump, any surplus being delivered to waste.

Some or all of the aspects and features of the invention described herein may be incorporated to advantage into a washing machine of the type disclosed and claimed in my copending PCT Application No PCT/GB00/01082 in that inter alia it allows an elliptical or pseudo elliptical drum to be reliably mounted for rotation in a sealed casing, which allows the pressure within the casing, and therefore the drum, to be raised or lowered relative to ambient.

According to a further aspect of the invention where the drum is cylindrical, blades may be fitted to extend radially externally and/or internally of the drum wall to assist in distributing air and liquid and diffusing vapour around the housing and the drum, and to assist in tumbling articles within the drum as it rotates.

Operation of a washing machine using heated liquid under pressure at 40°C and with the recirculation of the water as steam has enabled total wash and spin dry time for a 7kg load to be 10.2 minutes.

If a second pump is included so as to reduce the pressure in the housing and the drum significantly during drying and to achieve a full vacuum assisted drying cycle, the total

time required to fully dry a 7kg load can be 15-20 minutes, if heated air at 40°C is employed to speed up condensation in the vacuum drying cycle. Thus if the pressure wash and spin dry cycle takes 10.2 minutes a total wash and dry time of no more than 30.2 minutes can be achieved.

According to another aspect of the invention a perforated cylindrical basket may be fitted within the drum.

The basket and the drum are preferably of pseudo-elliptical cross-section.

The basket may have a tapering cross-section so that it is a tight push-fit in the drum.

A latch may be provided to retain the basket in the drum.

The basket may be formed from stainless steel or plastics.

Access to the basket may be through an open end thereof, and a radial flange may surround the opening.

According to a further aspect of the invention radially extending blades or paddles may be provided to radially extend from the drum (especially from the flats of the drum if the latter is of pseudo-elliptical cross-section), to scavenge the inside of the cylindrical casing as the drum rotates.

The rotation of the drum and therefore the blades or paddles, will lift water and/or detergent from the base of the casing and rotate it in an upward sense after which it will re-enter the drum and if provided, a basket in the drum through the perforations in the wall of the drum (and basket if provided). In doing so the liquid will be vigorously rotated and mixed with articles in the basket which are to be washed.

The invention will be described by way of example with reference to the accompanying drawings, in which:

Fig 1 is a diagrammatic cross section through a washing machine embodying aspects of the invention,

Fig 2 is a top plan view of the casing incorporated into the design of Fig 1,

Fig 3 is a front view in cross section of the casing and drum assembly of Figs 1 and 2,

Figs 4-11 illustrate other aspects of the invention,

Fig 12 illustrates a secondary drum or basket having a pseudo-elliptical cross-section which tapers slightly from the end containing the access opening to the other, for fitting into the drum of a washing machine as described herein,

Fig 13 is an end view of a drum such as a basket shown in Fig 12 can be located within, inside a stationary casing within which the drum and basket rotates,

Fig 14 is a side view of the basket drum and casing combination of Fig 13 partly cut away to reveal the perforated wall of the basket and showing the dual bearing and dual seal arrangement by which the drum is mounted for rotation, and

Fig 15 is a side elevation of a washer-drier embodying various aspects of the invention disclosed herein.

As shown in the drawings, the machine comprises a cabinet 10 having front wall 12, top 14, base 16 and side-walls, one of which is visible in Fig 1 at 18. A back wall (not shown) may be provided, typically removable to give access for servicing or repair.

Within the cabinet is mounted a cylindrical casing 20 the rear end wall 22 of which includes a central region of substantially increased thickness forming a hub 24 which has a central bore 26 within which are fitted the outer races 28, 30 of an assembly 32 of two bearings. The inner races 34, 36 of the two bearings are fitted to a shaft 38 which extends axially and centrally of the rear wall 40 of a drum 42.

The drum 42 may be circular or pseudo-elliptical in cross sectional shape, as shown in Fig 3.

The drum 42 has a perforated outer wall between two pseudo elliptical ends formed by rear wall 40 and front wall 44. The outer wall has two curved regions 46, 48 joined by two parallel flat regions 50, 52.

Within the drum and integrally formed with the rear end wall 40 is a spider reinforcement generally designated 54 having four limbs 56, 58, 60, 62 which extend parallel to the major and minor axes of the generally elliptical shape of the drum.

As best seen in Fig 1 the front end wall 44 of the drum 42 is centrally apertured to provide a circular opening 64 the rim of which is extended axially to form an externally protruding cylindrical lip 66. This protrudes into and is a clearance fit within a circular opening 68 in the front end wall 70 of the casing 20.

The casing is supported within the cabinet by means of inclined telescopic struts, two of which are shown at 72, 74 in Fig 1. Typically four such struts are provided to provide four mutually inclined legs for the casing.

Liquid can pass into the drum from the casing (and vice versa) via perforations in the outer wall 46 of the drum 42. Some of these can be seen at 76 in Fig 1.

The inclination of the struts is such that when the base 16 is standing on a flat horizontal floor, the casing can vibrate.

Vibration of the casing 20 can be set up by rotation of the drum 42 within the casing whilst containing an unbalanced load of articles to be washed or rinsed. This can generate out of balance forces of considerable magnitude while the drum is rotating, particularly after liquid has been supplied and the weight of the articles has increased due to retention of liquid in the material from which they are made.

The inclination of the struts allows vibration of the casing to occur in a front to back direction as well as in a generally vertical sense in the cabinet, and also allows more complex movement relative to the cabinet to occur involving varying horizontal and vertical components of motion.

Access to the drum is obtained through a circular opening 78 in the front wall 12 of the cabinet 10. The opening 78 can be closed and sealed by a door 80 (which may be transparent to allow the contents of the drum to be seen). An annular rim seal 84 forms a good fluid seal between the door and the cabinet wall, preventing the ingress or egress of liquid or air.

Between the rim seal 84 and the front wall 70 of the casing 20 is a cylindrical bellows seal 86 sealingly secured at one end to the inside surface of the front wall 12 of the cabinet 10 and at its other end to the forward facing surface of the front wall 70 of the casing 20. The bellows is formed from a resiliently deformable sleeve of plastics or rubber (or a composite thereof) and includes two helical coils of reinforcing wire, one embedded in the peaks of the corrugations and the other, of smaller diameter, embedded in the troughs of the corrugations. In this way the bellows is still capable of flexing and distorting to accommodate vibrational movement of the casing relative to the cabinet, but the reinforcement resists any tendency of the bellows to expand or contract due to differences in pressure between the inside and outside of the casing. Thus the closed interior of the casing, and therefore the drum, can be subjected to an over pressure or a vacuum, as required, during an enhanced washing, rinsing and drying process as described in my copending PCT Application No PCT/GB00/01082.

Around the cylindrical wall 88 of the casing 20 are located inlet and outlet ports. Thus 90 comprises a hot water inlet; 92 a cold water inlet; 94 a hot air inlet; 96 a wash liquid (or liquid detergent) inlet; 98 an outlet for connection to a pressure gauge (for monitoring the pressure in the casing), and 100 an outlet to which a vacuum pump can be attached, for removing liquid (after wash and rinse cycles), and removing air and vapour from the casing to assist in drying articles that have been washed and rinsed.

Typically the bellows seal 86 is compressed axially between the casing and the cabinet, and the uncompressed length of the bellows can be seen in Fig 2, as can the exterior of the hub 24 at the outer end of the casing.

As shown in Fig 1, an electric motor 102 is mounted to the rear wall 22 of the casing 20. The motor output shaft carries a pulley 104 and a pulley 106 is mounted on the stub shaft 38, which is driven by the motor through an endless drive belt 108.

Although described as having helical reinforcing and implying a helical corrugation in its cylindrical wall, the bellows may instead have a series of parallel spaced apart annular corrugations and the reinforcing may comprise endless rings of wire, larger diameter rings reinforcing the annular peaks of the corrugations and smaller diameter rings reinforcing the annular troughs of the corrugations.

The seal 84 is preferably a dual acting seal so as to resist both ingress and egress of liquid or air/gas/vapour.

As shown in Fig 1 the rear wall of the drum 42 also includes a thickened central region forming a hub 110 and an annular seal 112 is fitted between the hub 110 and the bearing assembly 32 to prevent ingress or egress of liquid or air/gas/vapour through the bearing assembly.

The races of the bearings are sealingly fitted within the hub 24 and around the stub shaft 38.

A header tank is shown at 114 in Fig 1 (and 158 in Fig 9). The tank (which serves as a reservoir) may be one of a plurality of separate tanks or part of a single partitioned tank, for containing various liquid(s) some of which are to be pumped into the casing. The tank (or partitioned region of a larger tank) 158 of Fig 9 forms part of a closed loop comprising the venturi pump 152, water outlet 160 from the latter for returning water to 158, water feed 159 and pump 154 for drawing water from 158 and pumping it under pressure to the venturi pump 152 to create the vacuum.

Pumps for increasing the pressure in the casing (and drum) and for applying suction to the outlet 100 are not shown.

As shown in Fig 1 blades such as 116, 118, 120 can be fitted to extend radially internally and externally of the wall of the drum, so as to improve distribution of washing liquid and the diffusion of vapour around the casing and drum, and in the case of the internally projecting blades, to assist in tumbling articles such as clothes within the drum as it rotates. Although such blades may be fitted internally to an elliptical drum, internal blades are of more need in a cylindrical drum.

In Fig 4 three connectors are shown at 110, 112 and 114 and an outlet at 116. 110 provides for connection to a pressure transducer and 112 and 114 water/soap and hot air (at 40°C) respectively, under control of solenoid valves. A large loading/unloading door is shown at 118 giving access to the interior of a cylindrical housing 120 within which a generally cylindrical perforated drum 122 is rotatable – see Fig 5.

A fully cylindrical perforated drum is shown in Fig 6 at 124. Ribs 126 strengthen the drum.

As shown in Figs 7 and 8 the housing 120 is located in a casing 128 by springs and compensators 130 if the drum is to be rotated at speeds in excess of 450 RPM. A solid mounting may be used in place of springs and compensators if lower rotational speeds are envisaged. One of the lower resiliently extensible and compressible support struts is shown at 131. Also shown in Fig 7 is a bellows assembly 132 into which a door 134 seals when shut. The bellows extends between the stationary housing 120 and the casing 128.

An annular sleeve or ring may be fitted around the bellows 132 to protect the latter, and prevent the bellows from over expanding radially when pressurised. In addition two or more straps may be located at equidistant points around the bellows 132 each strap being joined at one end to the casing 120 and at its other end to the cabinet wall 128. Two straps 133A, 133B are shown in Fig 7 and three straps 133A, 133C, 133D in Fig 7A.

The straps such as 133A, 133B may be of metal or plastics strip or plaited wire and permit lateral movement of the casing relative to the cabinet, but restrict axial movement of the casing relative to the cabinet and therefore prevent the casing from being pushed rearwardly in the cabinet when the casing and bellows are pressurised.

Tumble blades 136, 138, 140 extend radially into the drum 124 and the latter includes a circular opening 142 for loading and unloading through the bellows when the door is open.

A double or dual bearing assembly 144 supports the drum 124 centrally at its end opposite from that which engages the bellows. A shaft 146 extends beyond the bearing 144 on which is mounted a drive pulley for rotating the drum in known manner by means of an electric motor and endless belt (not shown). Two seals (not shown) are provided to prevent ingress of air when the drum/casing are evacuated and exit of air or water when the drum/casing are pressurised.

Fig 9 shows the rear of the drum and housing in cross-section and shows the tangential entrance 148 in the wall of the housing through which the diffuse mixture of water vapour and steam are pumped by the pump 150.

A solenoid valve 152 controls the admission of liquid from the housing to the pump and a heater 154 is located in the annular space between the drum and the housing to heat liquid just before it leaves the space for the pump.

A venturi pump 152 is supplied with water under pressure from a pump 154 driven by a motor 156 for supplying water under pressure to the pump from a reservoir 158 to which liquid removed from the housing by the venturi pump 152 is supplied via pipe 160.

Fig 8 also shows the tangential entrance 162 in the wall of the bellows 132 through which hot air can be introduced into the housing and via the bellows and opening 142 into the drum 124.

Fig 10 shows the essential parts if only spin drying is required – i.e. no venturi pump vacuum assisted tumble drying is provided for.

Fig 11 shows how aspects of the invention can be incorporated into a top loading washing machine. The cylindrical drum 170 is mounted within a stationary cylindrical housing 172 in a stationary casing 174. A hollow central tumbler 176 with blades 178 extends axially of the drum and a bellows 180 connects an open upper end of the 172 to a lid 182 having a dished central region which sealingly engages a cylindrical seal 184 at the upper end of the bellows 180.

A drain 186 allows liquid to pass from the housing via a solenoid valve (when open) to a pump 188 and an electric motor 190 drives the pulley 192 on the input shaft 194 of a gearbox 196 the output shaft of which carries the drum 170.

Liquid under pressure is pumped by 188 via solenoid valve 198 and pipe 200 into the hollow interior of the tumbler 176 to enter the interior of the drum via small openings 202 in the wall of the tumbler.

Small openings 206 in the wall of the drum allow liquid and air to pass into and out of the drum as required.

It is an advantage of using a drum such as shown in Fig 3 that the pseudo-elliptical cross-section causes articles such as clothing or bedding forming a load to be washed and/or dried, to tumble around the interior of the drum as the latter is rotated, without the need for inwardly directed tumble blades 136, 138, 140 such as are shown in Fig 7 – although if preferred such blades may also be included in pseudo-elliptical containers such as drum 42 or basket insert 208 of Figs 3 and 12 respectively.

Fig 12 illustrates a basket or secondary drum 208' in which there are two flat parallel non-perforated wall regions 210', 212' between the curved perforated wall regions 214', 216'. The right hand end (of Fig 12) is closed. The basket is adapted to slide axially into a similar drum 208 which carries an axially protruding drive shaft 218 (see Fig 13) by which the drum 208 is rotatably mounted in a dual bearing/dual seal support generally designated 220 (see Fig 14). A large diameter pulley 222 is keyed (see Fig 15) to the shaft 218 and an endless drive belt 224 extends therearound to transmit drive from a pulley 226 carried on the output shaft of a drive motor 228, itself mounted on a stationary casing 230, within which the drum is mounted.

The drum 208 includes perforated curved wall regions 214, 216 and flats 210, 212 corresponding to those of the basket 208'

The left hand end (in Fig 12) of the basket 208' contains a circular opening 232 through which articles to be washed can be inserted and from which washed and dried articles can be removed.

The cross-section of the basket 208' tapers slightly from the end containing opening 232 to the other closed end. The drum 208 into which the basket 208' fits is axially shorter than it would be if the basket were not to be used, as can be seen from Fig 14.

The wall regions 214', 216' contain a large number of small holes or perforations 234, through which air and water can pass in both directions as required. The taper allows the basket to be a tight fit in the drum.

Fig 15 shows a preferred arrangement for a front loading washer-drier, in which the axis about which the drum rotates is inclined to the horizontal as shown. This allows water to occupy the lower region of the inclined casing and drum, without relying on the seal around the opening 232 and/or the corresponding opening in the upper end of the casing 230, to retain the static head of water in the drum casing.

Fig 15 shows a bellows 236 which connects the upper end of the casing to the interior of a cabinet 238, an opening in the front wall 240 of the cabinet giving access to the basket and drum through an opening in the end wall of casing 230 and the opening 232 in the basket, via the bellows 236. A door 242 having at least one, and preferably two catches, is hinged to the cabinet, and when closed seals the opening in the cabinet against the exit of water from within the casing via the bellows, and also prevents the ingress of air when the casing 230 is evacuated. The door, and sealing therefor, may be as shown in Fig 7, except that here the seal is with the end of the bellows, since the latter are sealed to the casing 230.

In the cabinet of Fig 15, and below the inclined casing 230 is mounted a high vacuum venturi pump 244, a pump 248 for pumping water and detergent into the casing and drum, which can also pump water from a header tank 250 to operate the venturi pump, when required to draw liquid, and during drying, air from the casing. To this end the inlet to the venturi pump is connected via a pipe 252 to a drain outlet 254 (see also Fig 14) at or near the lowest point of the casing.

Water is pumped to a drain via a feed pipe (or return line) 258 so that the header tank is replenished as rinsing water is drawn from the drum/casing by suction, and only surplus water (i.e. not required to top up the header tank) passes to the drain via outlet 256. Water for operating the venturi pump 244 is drawn from the header tank via a pipe 260 which conveys the water to the inlet of the pump 262 which after pressurising the water pumps it to the venturi pump to create the vacuum therein.

The venturi vacuum pump may be operated so as to continually draw air and water vapour from the casing and drum during a drying cycle, even when heated air is being delivered to the casing. This produces a continuous dehydration of the interior of the casing and drum and of articles within the drum.

Referring again to Fig 13, a further modification is shown, comprising a pair of radially protruding blades 264, 266 extending from the flat wall regions 210, 212 of the drum. As the latter rotates in the cylindrical casing 230 the blades 264, 266 will sweep water ahead of them in the direction of drum rotation, and thereby lift the water in the casing from the lower part to the upper regions thereof from where the water will pass back into the drum through the perforations 234. This movement of the water is shown by the arrows 268, 270 with the direction of drum rotation being denoted by arrow 272.

The blades 264, 266 may extend axially over the whole length of the drum and can extend to the inside cylindrical surface of the casing 230, so as to wipe the latter in the form of a scraper blade.

The blades 264, 266 may be formed from metal or rubber or plastics or any combination thereof, so as to have an appropriate wear characteristic if they make contact with the inside of the casing as the drum rotates.

If they do not contact the casing, any gap is preferably very small so as not to reduce the pumping action of the blades as the drum rotates.

It has been found that by incorporating well fitting blades such as 264, 266 the second pump hitherto found desirable to circulate water and detergent for washing, or water for rinsing, can be dispensed with, since the suction and pumping effect produced by the rotating blades draws water and/or detergent into the casing when inlet valves (not shown) are opened and outlet valves (not shown) are closed, and will pump water and/or detergent from the casing when the valves are reversed.

As already mentioned the scavenging action of the blades lifts water from the lower regions of the casing into higher regions thereof, so that as the drum rotates, the water (and if present detergent also) is vigorously circulated within the casing and drum, passing through the openings in the walls 214, 216 of the drum and the corresponding openings in the walls 214', 216' of the basket.

The rotation of the blades 264, 266 has also been found to create an improvement in the diffusing of the liquid within the casing and drum.

As shown in Fig 15, hot air can be introduced into the bellows 236 by a pipe 274.

The inner basket 208' may be formed from an open wire mesh or the like and can be fitted within the drum 208 permanently, or may be removably mounted therein. The inner basket comprises a second washing and drying drum.

As best seen in Fig 14 the basket 208' is axially longer than the drum 208 and is constructed so as to be a close fit within the drum 208. Since both have flats 210, 212 in the case of drum 208 and 210', 212' in the case of the basket 208', rotation of the drum 208 is reliably transmitted to the basket 208', when the latter is fitted therein.

The basket 208' includes a lip 209 around the opening 232 in its end, and the lip can be seen in Fig 14 closing the gap between the outer rim of the basket and the stationary casing 230. Although as shown in Fig 12 the lip 209 may have two flats similar to those of the drum and basket cross-section, this is not essential, and the lip 209 may be an annular

member which fits closely within the cylindrical casing 230, so that the annular gap between the basket and casing is fully protected all round.

The inner drum or basket 208' may be formed from stainless steel or plastics.

Referring again to Fig 15, where a second pump 276 is required, this can be mounted below the elevated front end of the inclined casing 230 and water and detergent can be pumped by 276 into the casing 230 via pipe 278.

If the blades 264, 266 are fitted to the drum, there may not be any requirement for this second pump 276.

Where an inner drum or basket 208' is employed, a latch or other device (not shown) may be provided to retain the basket 208' in the drum 208, and prevent it working loose (in an axial sense) during rotation of the drum.

Claims

1. A washing machine of the type described wherein a drum containing casing is mounted on a plurality of legs which extend between the exterior of the casing and the interior of a cabinet.
2. A washing machine as claimed in claim 1 wherein the legs extend between the casing and the floor and/or lower regions of the side walls of the cabinet.
3. A washing machine as claimed in claim 2 wherein at least one additional leg extends between the exterior of the casing and an upper region of a sidewall of the cabinet.
4. A washing machine as claimed in any of claims 1 to 3 wherein each leg includes or comprises a shock-absorbing device, in order to accommodate out of balance forces when the drum is rotating in the casing.
5. A washing machine as claimed in claim 4 wherein each leg comprises an extensible two part strut, relative movement between the two parts of which is governed by a spring.
6. A washing machine as claimed in claim 5 wherein the unrestrained length of each strut is greater than the distance between the casing and the cabinet which it is to span, so that when the casing is mounted within the cabinet the struts are partly compressed, so enabling each strut to increase and decrease in length, its spring thereby becoming less or more compressed as it does so, to accommodate the changes in overall length.
7. A washing machine as claimed in claim 5 or 6 wherein the struts extend in directions which are not radii of the cylindrical casing, at an acute angle to the casing and the cabinet, so that any change in length can be considered as dimensional changes in

directions parallel and perpendicular to a plane containing the axis of rotation of the drum.

8. A method of supporting a drum-containing casing within a washing machine cabinet by means of a plurality of resiliently compressible and extensible struts between the casing and the cabinet, whereby the casing floats within the cabinet and is capable of relative movement therewithin during rotation caused by unbalanced loading of the drum.
9. A washing machine of the type described wherein a drum containing casing is located within an external casing, having an access opening in one wall thereof for giving access to the interior of the casing and drum, in which the drum includes an axially extending stub shaft which is received in and supported by a bearing assembly carried in or by an end wall of the casing opposite the wall containing the access opening.
10. A washing machine as claimed in claim 9 wherein the bearing assembly comprises two sealed ball or roller bearings the outer race of each of which is secured within a hub-extension of the end wall of the casing and the inner race of each of which is secured to the stub shaft extending from the drum.
11. A washing machine as claimed in claim 10 wherein one or more seals which prevent air or liquid from escaping therethrough, are located between the bearing assembly and the drum.
12. A washing machine as claimed in any of claims 9 to 11 wherein a pulley is keyed or splined to the stub shaft where it extends beyond the bearing assembly.
13. A washing machine as claimed in claim 12 wherein an electric motor is mounted to drive the stub shaft via a drive belt which extends around a drive pulley on the motor shaft and the pulley on the stub shaft.

14. A washing machine as claimed in claim 13 wherein a gearbox is provided driven by the electric motor, for driving the drive pulley, with the drive pulley mounted on the output shaft of the gearbox.
15. A washing machine as claimed in any of claims 1 to 7 or 9 to 14 in which the drum is to rotate at speeds in excess of 450rpm so as to spin dry the articles and where a cylindrical sleeve, capable of axial enlargement and contraction, but resistant to circular enlargement or contraction, is sealingly secured at one end around a circular access opening in an end wall of the casing and at its other end around a circular access opening in the cabinet wall.
16. A washing machine as claimed in claim 15 wherein the sleeve is formed with at least one radial corrugation to form a cylindrical bellows, and at least one loop of wire surrounds or is embedded in the wall of the corrugated sleeve so formed to resist circular enlargement or contraction of the sleeve, without interfering with the ability of the sleeve to axially expand or contract and/or for one end to be displaced laterally relative to the other due to vibration of the casing relative to the cabinet.
17. A washing machine as claimed in claim 16 wherein the sleeve is formed with at least one spiral corrugation the peaks and/or troughs of which are reinforced with one or more wire spirals.
18. A washing machine as claimed in claim 17 wherein a smaller radius spiral is embedded in the troughs, while a larger radius spiral is embedded in the peaks of the spiral corrugations of the sleeve material.
19. A washing machine as claimed in claim 16 or 17 wherein circular or radial displacement of the casing due to out of balance forces during rotation of the drum is accommodated by distortion of the corrugated sleeve with one end moving relative to the other end of the sleeve in planes perpendicular to the axis of the sleeve.

20. A washing machine as claimed in any of claims 16 to 19 wherein the corrugated sleeve allows the pressure within the casing to be greater or less than ambient without interfering with the integrity of the seal between the casing and the cabinet.
21. A washing machine as claimed in any of claims 15 to 20 wherein the sleeve comprises a cylindrical bellows of stainless steel or plastics or rubber or a composite of rubber and plastics or a combination of any of the aforesaid.
22. A washing machine as claimed in any of claims 1 to 7 or 9 to 14 in which the maximum speed of the drum is to be 450 RPM such that drying is only achieved to a damp-dry condition, wherein a flange of stainless steel, plastics, rubber or a composite thereof is sealingly secured between the casing and the cabinet wall in the region of the access opening for sealing the interior of the drum.
23. A washing machine wherein a drum-containing casing is supported within a cabinet so as to permit relative vibratory movement between the casing and the cabinet, wherein the interior of the casing is sealed against loss of liquid and can accommodate an internal pressure above or below ambient, in which the support comprises resiliently extensible struts between the casing and the cabinet which generally centre the casing therewithin, and a corrugated bellows surrounds and seals a circular opening in an end wall of the casing and at its other end a circular opening in an adjacent wall of the cabinet, which latter is closable by means of a door which seals to the opening therein, and the corrugations are reinforced by at least one reinforcing helix or spiral in the form of a helical spring, which prevents the material forming the bellows sleeve from stretching or collapsing due to an increase or decrease in the pressure within the casing relative to ambient pressure outside the casing.
24. A washing machine as claimed in claim 23 wherein the reinforcement is of wire or a rigid plastics material.

25. A washing machine as claimed in claim 24 wherein an inner rim of the circular access opening in the cabinet wall is lined with a resiliently deformable annular seal, and the door extends at least partly into and through the end of the bellows when the door is closed, and forms with the annular seal a fluid tight seal which resists inward or outward flow of air or liquid when the door is fully shut.
26. A washing machine as claimed in claim 25 wherein an internally protruding part of the door sealingly engages the ring of resiliently deformable seal material around the cabinet opening.
27. A washing machine as claimed in claim 26 wherein the annular seal around the rim of the opening in the cabinet wall is formed by, or secured to, an annular region of the cabinet-engaging end of the corrugated bellows.
28. A washing machine as claimed in claim 27 wherein a lip extends from the rim of the circular opening in the drum to close the circular opening in the casing, so that there is little tendency for articles or parts of articles in the drum to become drawn into the gap between the drum and the casing.
29. A washing machine as claimed in claim 28 wherein a clearance between the outside of the lip and the circular opening in the casing allows for rotation of the drum relative to the casing.
30. A washing machine as claimed in any of claims 1 to 7 or 9 to 29 wherein the drum is circular or pseudo elliptical, when viewed axially.
31. A washing machine as claimed in claim 30 wherein the major axis of the generally pseudo elliptical shape is less than the internal diameter of the cylindrical casing, so that the drum is capable of rotating freely therewithin.

32. A washing machine as claimed in any of claims 1 to 7 or 9 to 31 wherein strengthening ribs are provided extending along perpendicular diameters of a cylindrically shaped drum, or the major and minor axes of a generally elliptically or pseudo elliptically shaped drum.
33. A washing machine as claimed in claim 32 wherein the ribs extend internally of the drum.
34. A washing machine as claimed in claim 32 wherein the ribs extend parallel and close to, internally or externally of the drum, in contact with, or attached as by welding or riveting or an adhesive to, or are formed integrally with, the end wall of the drum opposite the end containing the access opening.
35. A washing machine as claimed in any of claims 1 to 7 or 8 to 34 wherein water and detergent inlet ports, an air inlet port, an outlet port and a connection for a pressure gauge are located at a plurality of circularly spaced points around the cylindrical wall of the casing.
36. A washing machine as claimed in any of claims 1 to 7 or 8 to 34 wherein three inlet ports are provided, one for admitting hot or cold water or soap, a second for admitting heated air, and a third for admitting fluid into the drum to which liquid is supplied from a circulating pump which collects liquid from the housing and recirculates it under pressure back into the housing, together with an outlet port.
37. A washing machine as claimed in claim 36 wherein the air is heated to 40°C.
38. A washing machine as claimed in claim 35 or 36 wherein the third inlet introduces fluid tangentially into the drum.
39. A washing machine as claimed in claim 35 or 36 wherein the outlet port is at a remote location around the casing from the inlet ports.

40. A washing machine as claimed in claim 39 wherein the outlet port is situated at a point around the casing which, when the latter is located within the cabinet and the latter is upright, will be at the lowest point of the casing, to facilitate the removal of liquid from the casing as by draining and/or suction withdrawal.
41. A washing machine as claimed in any of claims 1 to 7, or 8 to 40 wherein a heater is provided between the outer wall of the drum and the wall of the casing within which the drum is located and rotated, which heater is employed to heat liquid before it leaves the casing to be pumped under pressure back into the casing, thereby to allow a mixture of water vapour and steam to be pumped back into the casing and thereby the drum, and also to allow water at a lower temperature of around 40°C to be employed initially, this water being withdrawn and heated and converted to steam for injection under pressure back into the drum.
42. A washing machine as claimed in claim 41 wherein a diffuse mixture of water and steam is pumped into the casing and thereby the drum during washing, via an opening in the bellows.
43. A washing machine as claimed in claim 42 wherein the said opening in the bellows is employed to supply air to the casing during spin drying, or the diffuse mixture of water vapour and steam during washing, depending on the operation of one or more valves controlling the fluid which is supplied thereto.
44. A washing machine as claimed in any of claims 1 to 7 or 9 to 43 wherein during drying air and water are drawn out of the casing by means of a suction pump so that a pressure lower than ambient exists in the casing during drying, and the same pump is employed to draw water out of the casing during washing and rinsing, the extracted water passing from the pump to a drain, or via a pipe means to an opening in the drum for recirculation under pressure.

45. A washing machine as claimed in claim 44 wherein the suction pump is a venturi pump, preferably a high vacuum venturi pump.
46. A washing machine as claimed in any of claims 43 to 45 wherein heated air is introduced into the drum via an opening in the wall of the bellows at one end of the rotatable drum, so that heated air can reach the central region of the drum in general without having to pass through items in the drum, but in general will have to pass through those items before it can leave the drum via openings in the wall of the drum and thereafter via one or more openings in the stationary casing.
47. A washing machine as claimed in any of claims 1 to 9 or 9 to 46 wherein a positive pressure over ambient is maintained in the casing and the drum during washing.
48. A washing machine as claimed in claim 47 wherein the positive pressure is in the range 1 to 5 psi over ambient.
49. A washing machine as claimed in any of claims 1 to 7 or 9 to 48 wherein blades are fitted to extend radially of the drum wall.
50. A washing machine as claimed in claim 49 wherein the blades protrude internally to assist in distributing air and liquid and diffusing vapour around the drum, and to assist in tumbling articles within the drum as it rotates.
51. A washing machine as claimed in claim 49 wherein the blades protrude externally of the drum to assist in distributing air and liquid and diffusing vapour within the casing.
52. A washing machine as claimed in claim 51 wherein the blades extend close to an internal cylindrical surface of the casing so as to effect a scavenging action in the casing as the drum rotates thereby acting as paddles to lift water from lower regions of the casing to higher regions of the casing to fall back into the drum through perforations in the wall of the drum.

53. A washing machine as claimed in any of claims 1 to 7 or 9 to 52 wherein a second drum having perforations in its wall to allow air and liquid to pass therethrough is fitted into the first mentioned drum.
54. A washing machine as claimed in claim 53 wherein the second drum is in the form of a cylindrical basket.
55. A washing machine as claimed in claim 53 or 54 wherein the second drum is removable from the first drum.
56. A washing machine as claimed in any of claims 53 to 55 wherein the first and second drums each have a pseudo-elliptical cross-section by virtue of flat parallel wall regions which extend between curved end wall regions.
57. A washing machine as claimed in claim 56 wherein radial paddles extend externally from the parallel flat wall regions.
58. A washing machine as claimed in either of claims 56 and 57 wherein only the curved end wall regions are perforated.
59. A washing machine wherein a drum-containing casing is supported within a cabinet so as to permit relative vibratory movement between the casing and the cabinet, and a flexible sleeve surrounds and seals a circular opening in an end wall of the casing and at its other end a circular opening in an adjacent wall of the cabinet, which latter is closable by means of a door which seals to the opening therein.
60. A washing machine as claimed in claim 59 wherein the sleeve is of stainless steel.
61. A method of operating a washing machine constructed as claimed in claim 15, 23, 59 or 60 wherein the sleeve includes an opening through which fluid can pass to or from

the interior of the drum, wherein during a tumble drying step hot air is introduced into the drum via the opening in the sleeve whilst a vacuum pump is operated to create a pressure below ambient in the casing, wherein the vacuum pump is operated continuously during the tumble dry cycle, so as to maintain the lower than ambient pressure and also remove the hot air.

62. A method of operating a washing machine constructed as claimed in claim 15, 23, 59 or 60 in which water that has been used for washing or rinsing is re-used by pumping it under pressure to the venturi pump.
63. A method as claimed in claim 62 wherein the water is stored in a reservoir in the machine before being pumped under pressure to actuate the venturi pump.
64. A method as claimed in claim 63 wherein the reservoir is topped-up with water as it is drawn from the drum casing and any surplus is delivered to waste.
65. A method as claimed in any of claims 8 and 61 to 64 wherein paddles extend from the drum and rotate therewith and co-operate with the internal casing wall to act as a radial pump for drawing air and/or liquid into the casing and pumping air and/or liquid therefrom.
66. A washing machine as claimed in claim 15, 23, 59 or 60 wherein flexible links join the drum containing casing to the cabinet, which allow relative lateral movement, but limit relative axial movement therebetween.

1/12

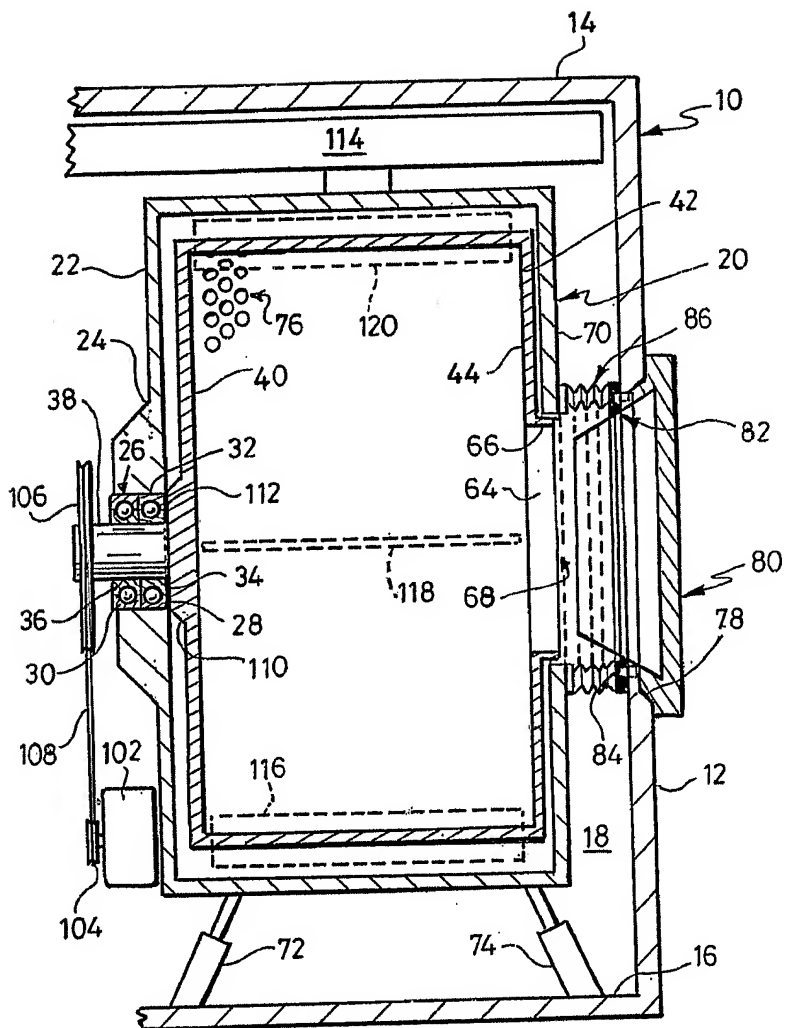


Fig. 1

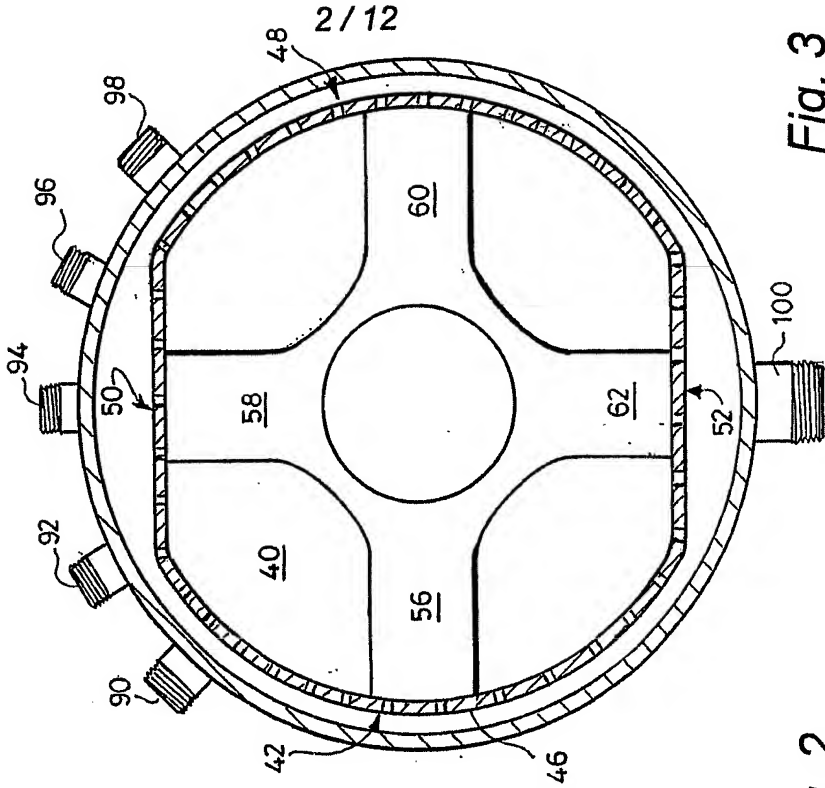


Fig. 3

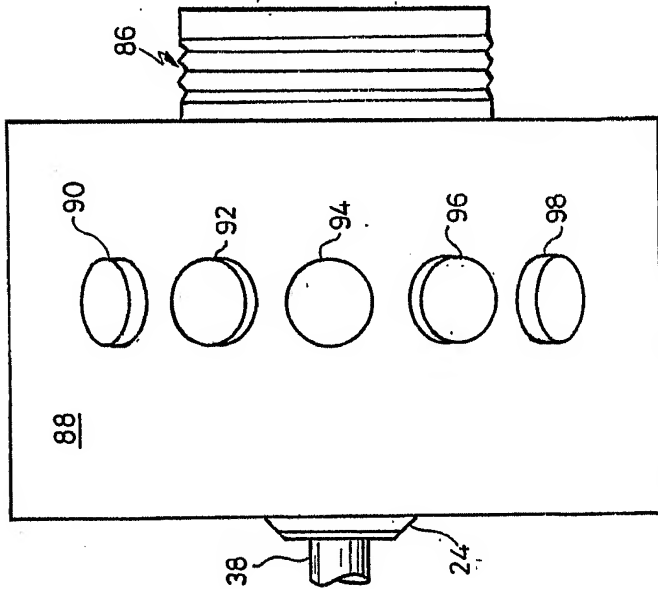
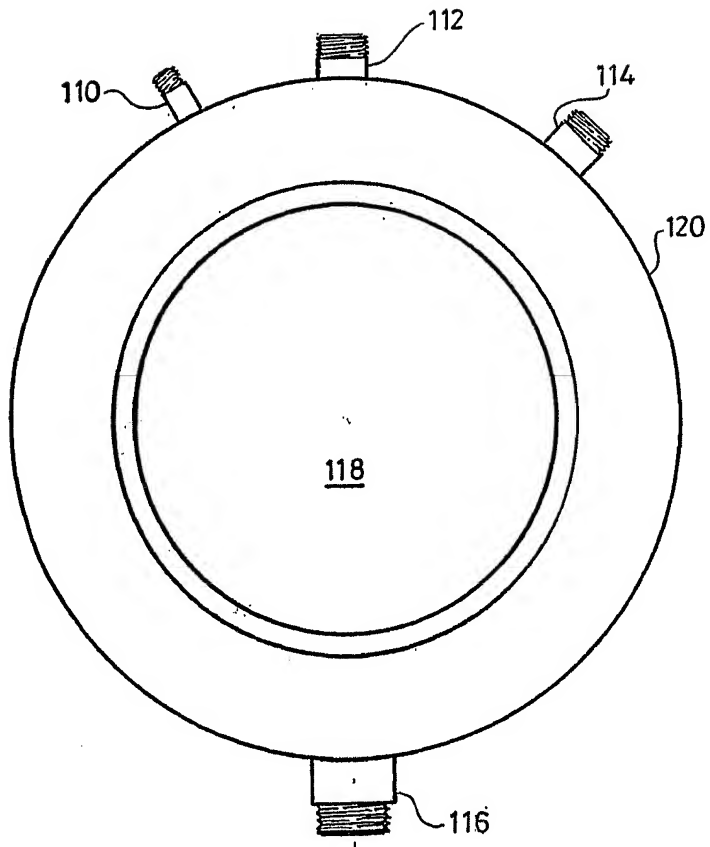
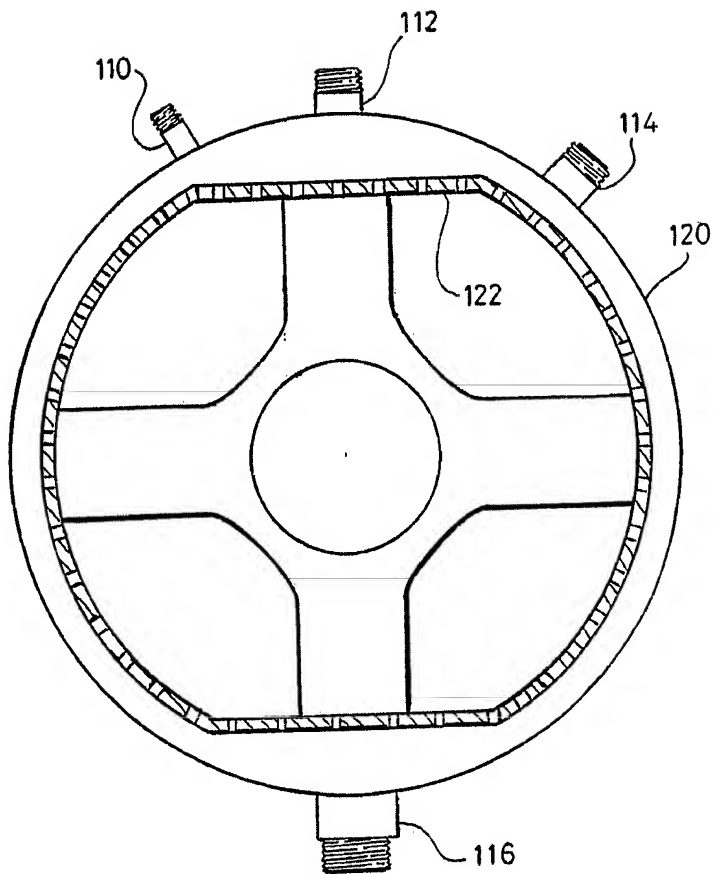


Fig. 2

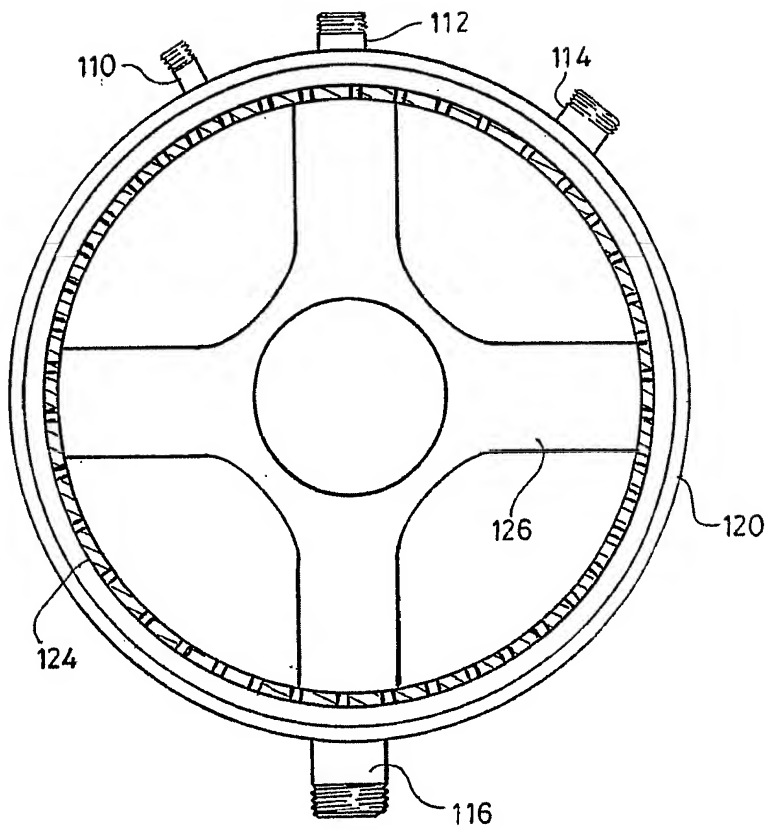
3/12

*Fig. 4*

4/12

*Fig. 5*

5/12

*Fig. 6*

6 / 12

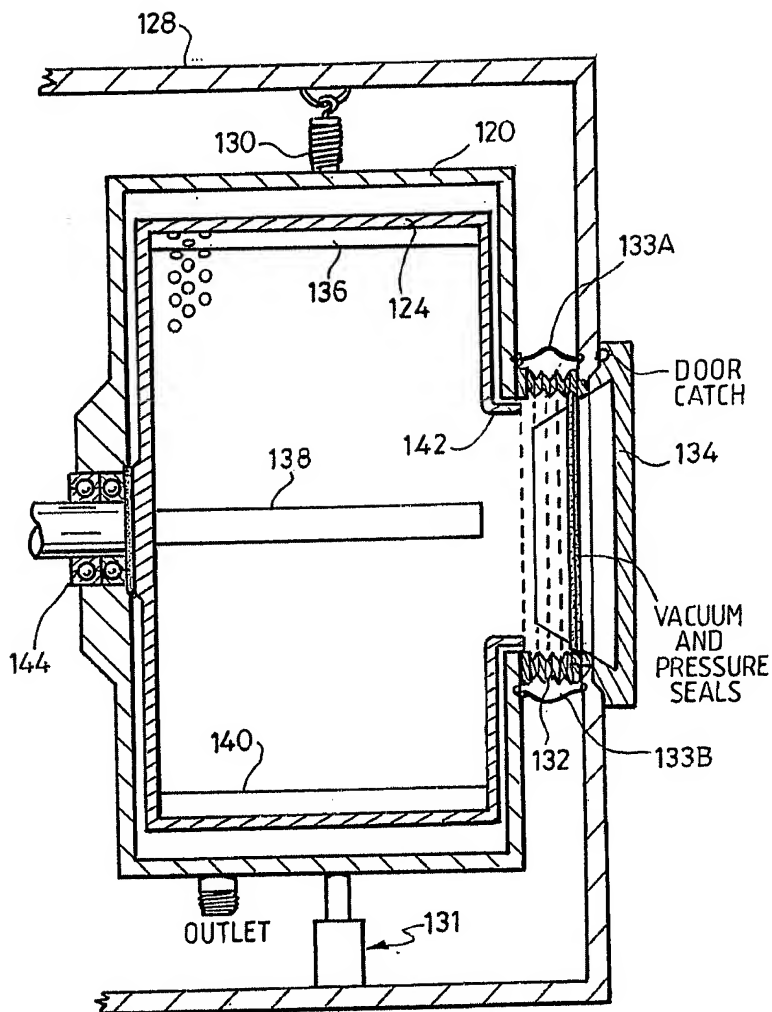
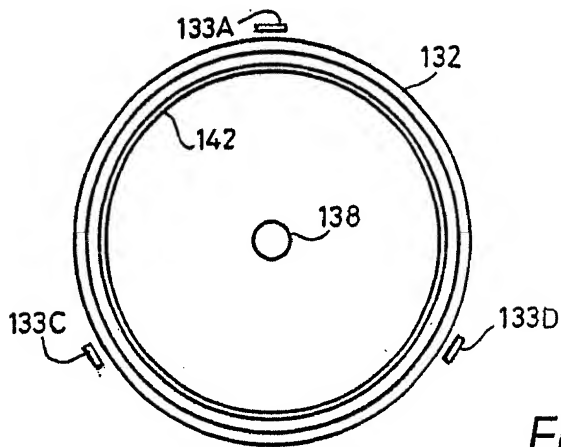
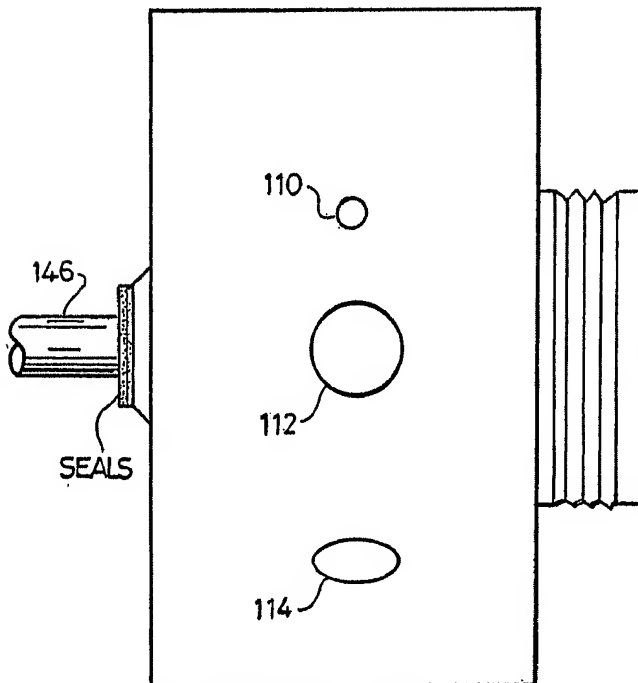


Fig. 7

7/12

*Fig. 7A**Fig. 8*

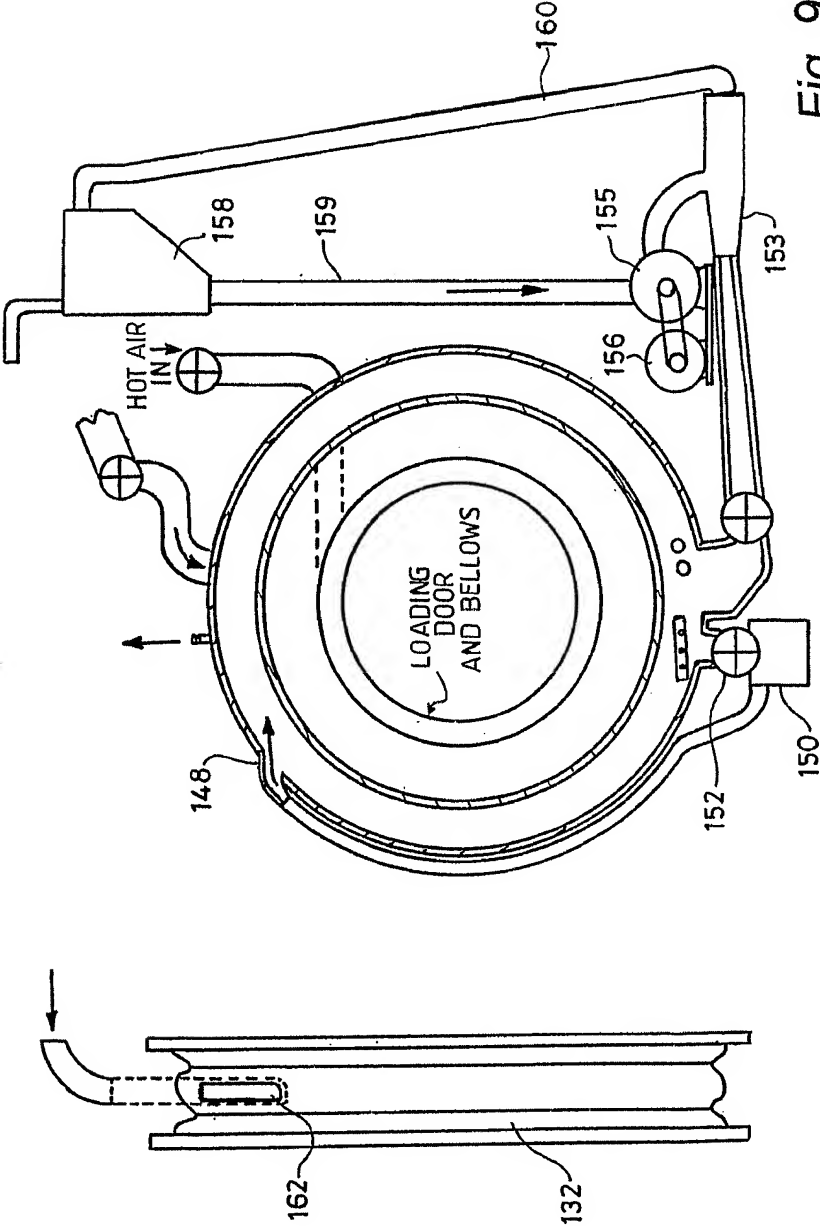
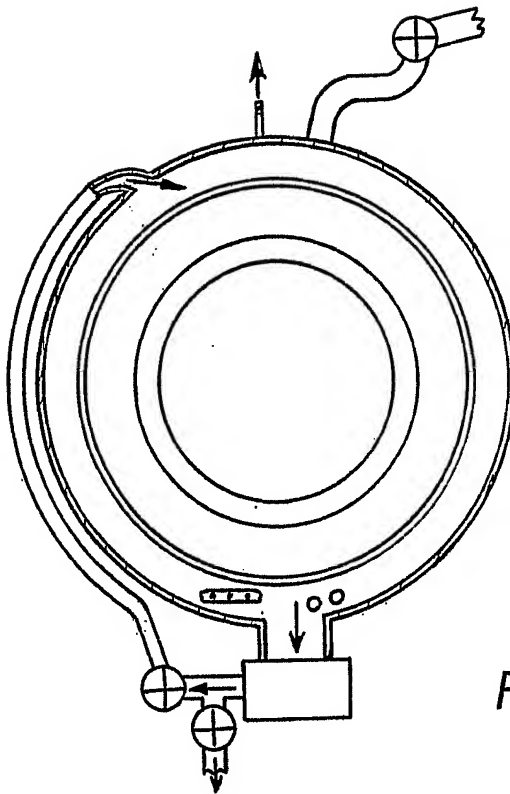


Fig. 9

9 / 12

*Fig. 10*

10/12

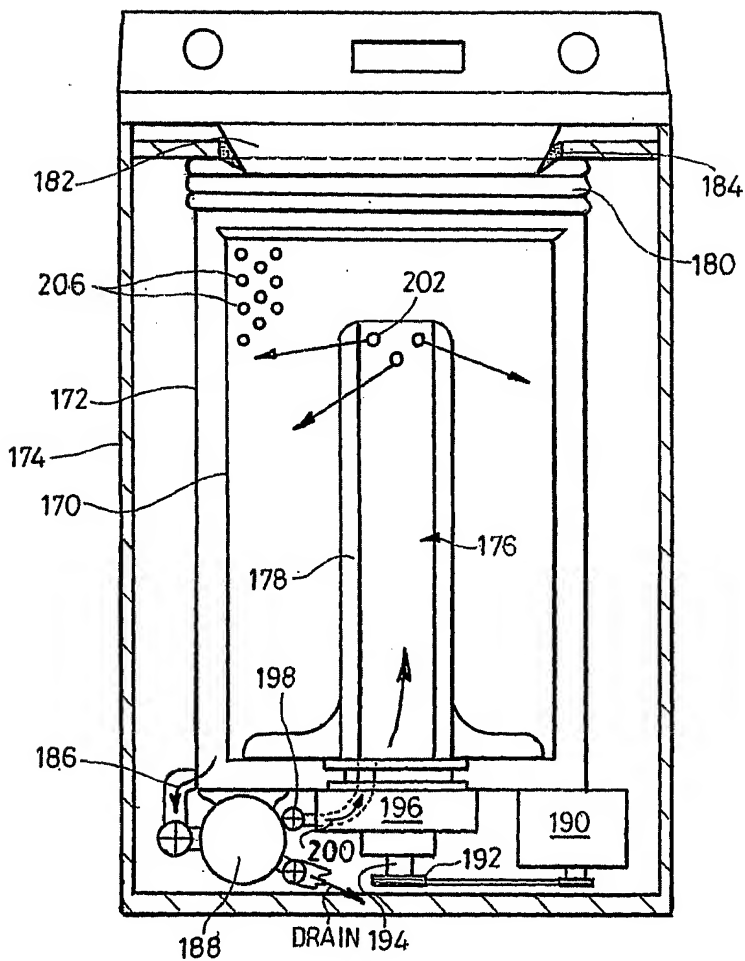


Fig. 11

11/12

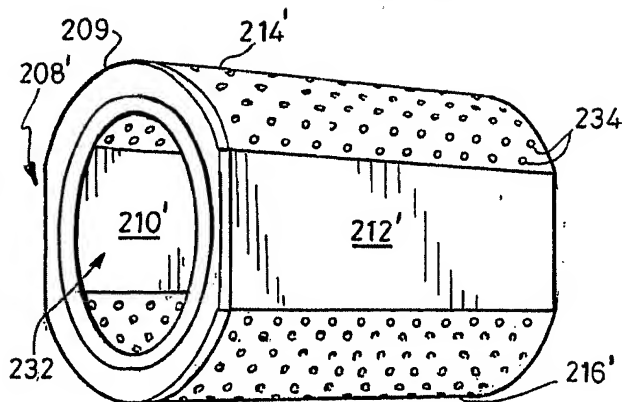


Fig. 12

Fig. 13

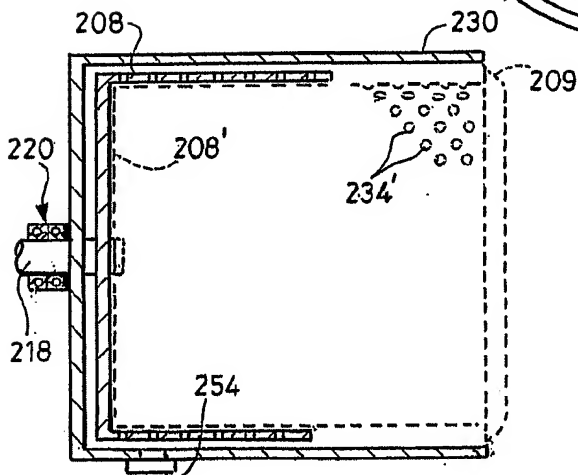
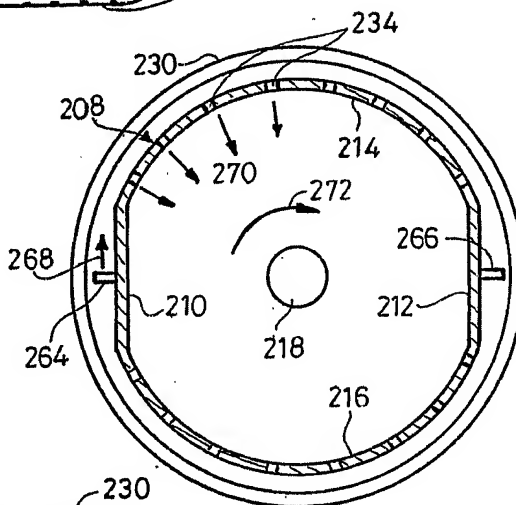
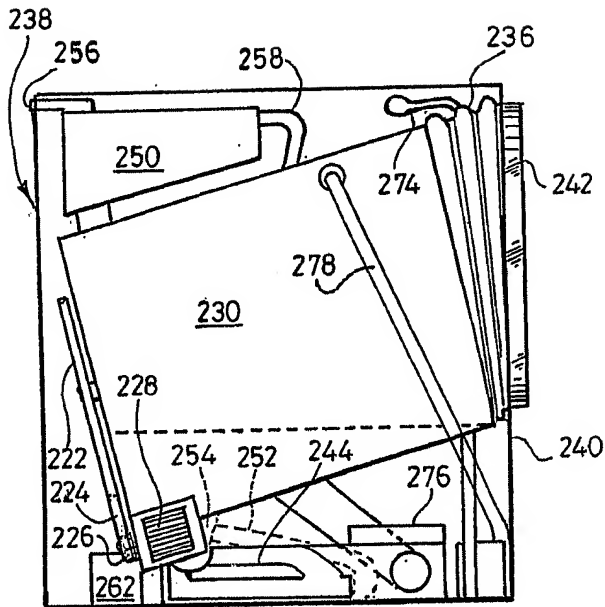


Fig. 14

12/12

*Fig. 15*